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UNITED STATES DEPARTMENT OF AGRICULTURE

BULLETIN No. 1066

Contribution from the Bureau of Entomology

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Washington, D. C. ▼ **June 21, 1922**

CURCULIOS THAT ATTACK THE YOUNG FRUITS AND SHOOTS OF WALNUT AND HICKORY.

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INTRODUCTION.

Several species of snout-beetles nearly related to the common plum curculio (*Conotrachelus nenuphar* Hbst.) attack the immature fruits, tender shoots, and leaf petioles of walnut and hickory. Four such species are discussed herein, all belonging to the genus Conotrachelus and all having evidently at times been confused under the one most familiar species, *Conotrachelus juglandis* Lec. The four species throughout the several stages of their development resemble one another closely in appearance, habits, and seasonal activities, except that they select different food plants or have different methods of attack.

Several members of this group attack acorns and there are also several species of an allied group of snout-beetles (genus Balaninus) the larvæ of which feed in mature, or nearly mature, chestnuts, hickory nuts, hazelnuts, and acorns. These are not dealt with in this bulletin.

THE BUTTERNUT CURCULIO.[1]

The butternut curculio has been known commonly in the past either as the " walnut weevil " or " walnut curculio." It would seem that for the members of this group whose larvæ feed in immature nuts the term " curculio " is to be preferred in order to disassociate them in the popular mind from members of the Balaninus group, which have long been known as "nut weevils." The other part of the name is here restricted to " butternut " for the reason that this species appears to confine its attacks almost exclusively to our native butternut (*Juglans cinerea*) and to introduced walnuts of the butternut type. There is a very similar but distinct species to which the name " walnut curculio " could be applied with equal appropriateness. In rearing several hundred specimens the writer has failed to obtain a single individual of *C. juglandis* from infested young black walnuts (*Juglans nigra*), the species commonly attacking black walnuts being *Conotrachelus retentus* Say, described on pages 7–11. One beetle of *C. retentus* was found among a lot of beetles of *C. juglandis* reared from butternuts, and it is possible that with both species of insect there is occasional interchange of hosts.

The butternut curculio also attacks and injures seriously the fruit and small branches of various species of introduced walnuts, being especially destructive to the Japanese walnuts (*J. sieboldiana* and *J. cordiformis*) which are of the butternut type. (Pl. II, *D;* Pl. III, *B.*)

DISTRIBUTION.

The known range of the butternut curculio extends from the Provinces of Ontario and Quebec, Canada, south through the New England States, Wisconsin, Iowa, and Kansas to Alabama and Georgia. Britton and Kirk[2] record it from 20 States within the boundary just given. The distribution of the insect follows rather closely the natural range of the butternut, which is its favorite native food plant. Throughout the general range of the insect there are evidently many localities, even where host trees abound, in which it is very rarely found. In many other localities it is abundant and destructive.

FOOD PLANTS.

Britton and Kirk[2] give the food plants in the order of preference shown as follows: *Juglans cordiformis*, *J. sieboldiana*, *J. cinerea*, *J. regia*, *J. nigra*, and *J. mandshuria*. They quote Dr. Robert T. Morris, a nut grower, of New York City and Stamford, Conn., as stating that he has observed this curculio on various species of hickory. Blatchley and Leng[3] record the species as "occurring on walnut, butternut, and hickory, the larvæ breeding in the green fruit."

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[1] *Conotrachelus juglandis* Lec.; suborder Rhynchophora, family Curculionidae, tribe Cryptorhynchini.

[2] BRITTON, W. E., and KIRK, H. B. LIFE HISTORY AND HABITS OF THE WALNUT WEEVIL OR CURCULIO. *In* 12th Ann. Rept. State Ent. Conn., p. 240–253. 1912.

The present writer has found this curculio attacking extensively the fruit of our native butternut (*J. cinerea*) and the shoots and leaf petioles of the Japanese walnuts (*J. sieboldiana* and *J. cordiformis*). It was found less frequently feeding and ovipositing in the shoots of the native butternut and the fruits of the Japanese walnuts. Several beetles were found in September on the branches of a young tree of *Juglans cathayensis* growing in Arnold Arboretum, at Boston, Mass., and there were evidences of serious injury to the branches made earlier in the season by the larvæ. Similar although less extensive injury was noted on a tree of the same species growing in one of the parks of Rochester, N. Y.

NATURE AND EXTENT OF INJURY.

The injury inflicted by this insect consists of feeding punctures made by the adults in the nuts, tender tips, and leaf petioles and the burrows of the larvæ in the nuts and new growth of various species of walnuts. Extensive injury has been reported from Connecticut,[4] where young transplanted trees and trees in the nursery row have been partially or entirely killed by the larvæ working in the branches. The most serious loss of this kind has been to the Japanese walnuts, although trees of the Persian walnut have suffered to some extent. Britton and Kirk[5] describe infestation in one nursery as follows:

> In a nursery at New Canaan [Conn.], about the middle of September, Mr. Kirk noticed a row containing about 265 trees of *Juglans sieboldiana* on all of which the larvæ were tunneling in the new growth. An adjoining row of about the same number of *J. regia* trees was only slightly attacked, and another adjoining row containing about 400 trees of black walnut, *J. nigra*, were uninfested. Several hundred other trees of *J. sieboldiana* in another part of the same nursery were badly infested, not a single tree escaping. Here, also, was noticed the fall attack of the adults at the base of the leaf petioles, and two adults were collected.

During the present investigation the writer has observed serious injury to young trees of *J. siebaldiana*, *J. cordiformis*, and *J. cathayensis* in Massachusetts, Connecticut, and New York. Southward, particularly in Maryland and West Virginia, extensive attacks upon the fruit of the native butternut occur regularly. Many cases have been observed in which 50 per cent or more of the nuts dropped from trees prematurely on account of injury by the curculio larvæ, the percentage of loss being greatest in years of light crops. Farther north attacks upon the fruit of the native butternut seem less extensive, although at least a few infested nuts can usually be found upon or beneath any bearing tree. A case of slight injury to the nuts was found in 1920 in Jefferson County, N. Y. At nearly the same time about 20 bearing butternut trees were examined along the St. Lawrence River, in St. Lawrence County, N. Y., and not a trace of the insect found. Beetles were reared from both shoots and fruit of *J. sieboldiana* collected at Lockport, N. Y., and larvæ were abundant in butternuts collected at Lake Winnepesaukee, in central New Hampshire.

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[3] BLATCHLEY, W. S., and LENG, C. W. RHYNCHOPHORA OR WEEVILS OF NORTHEASTERN AMERICA, p. 469. 1916.

[4] BRITTON, W. E., and KIRK, H. B. Op. cit.

Occasionally the larvæ are found boring in young shoots of butternut at French Creek, W. Va., oviposition evidently taking place in the tips of these shoots before the fruit is large enough to be attacked. On July 2, 1920, in the last-named locality, 60 half-grown butternuts were picked at random from the lower branches of one tree. Of these 60 nuts 48 contained egg punctures of the curculio and 12 were sound. A number of nearly full-grown larvæ were also found boring in the terminal shoots and leaf petioles. These larvæ averaged larger than those in the nuts, indicating, as in numerous other observations made, that eggs are first laid in the shoots.

LIFE HISTORY.

The butternut curculio has but one generation annually, and, like other members of the genus, passes the winter in the adult stage. In West Virginia oviposition begins in May and continues practically all summer, apparently reaching its maximum the last of June or the first of July.

EGG.

The egg is oblong, oval, creamy white, with the surface like ground glass. (Pl. I, *D* and *E*; Pl. II, *A*, *B*, and *C*.) Three measured on July 2, 1920, were uniformly 1 mm. long by 0.6 mm. wide. Two measured on June 7, of the same year, were 0.9 mm. long by 0.6 mm. wide. Britton and Kirk[5] give the following dimensions: Length, 0.95 mm.; thickness, 0.57 mm. Most of the eggs hatch in from 8 to 10 days, although the period may extend to 15 days.

LARVA.

The larvæ are whitish, or dirty white, with brown head and blackish mandibles. (Pl. II, *D*; Pl. III, *A* and *B*.) The length is 12 to 13 mm. and the thickness 3 mm. Feeding in the nuts and shoots, they become full grown in four or five weeks and then enter the ground to pupate. Nuts that are attacked when very small usually furnish

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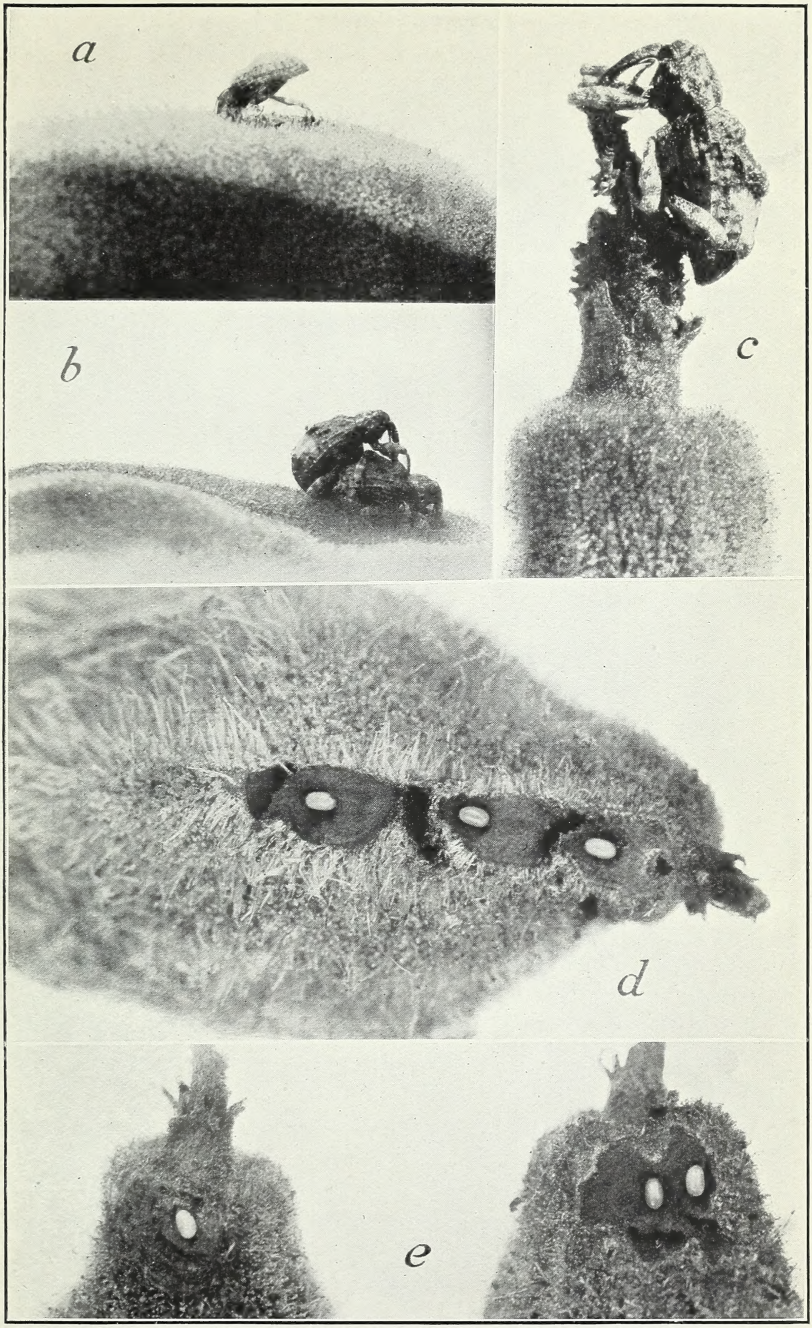
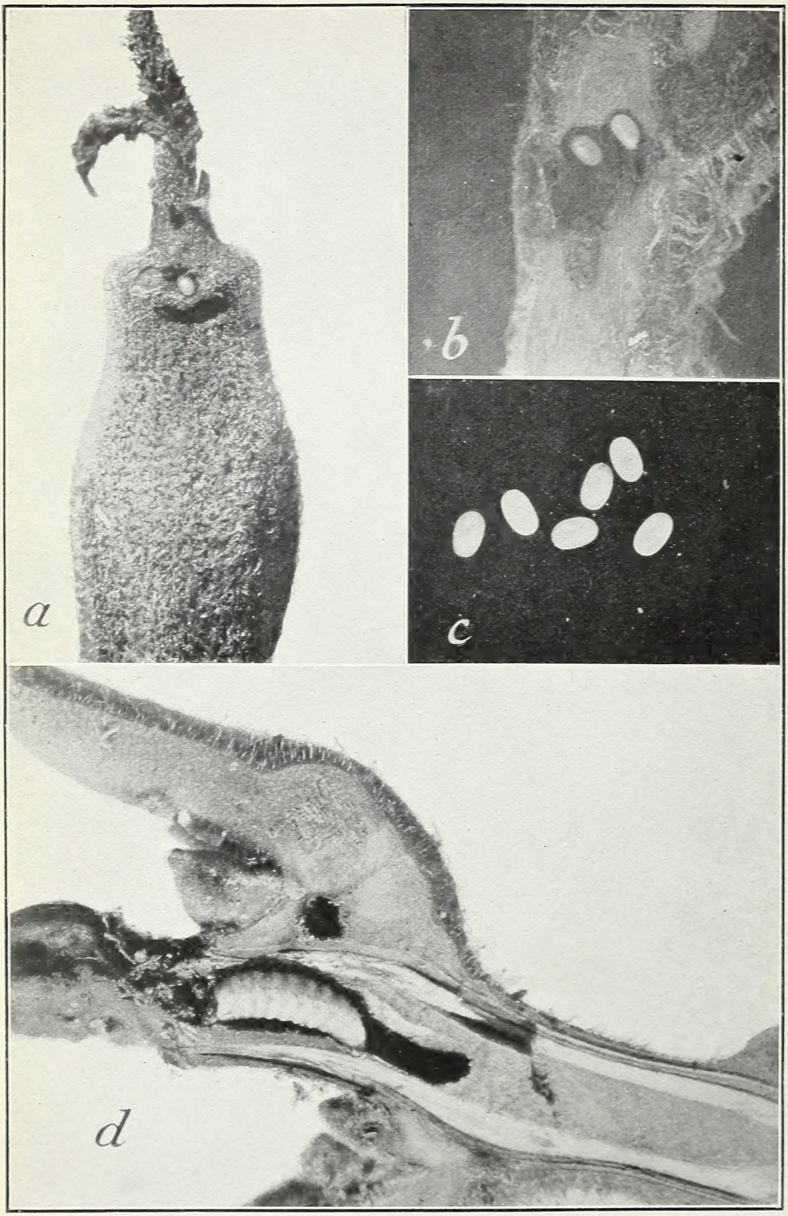
[5] BRITTON, W. E., and KIRK, H. B. Op. cit.



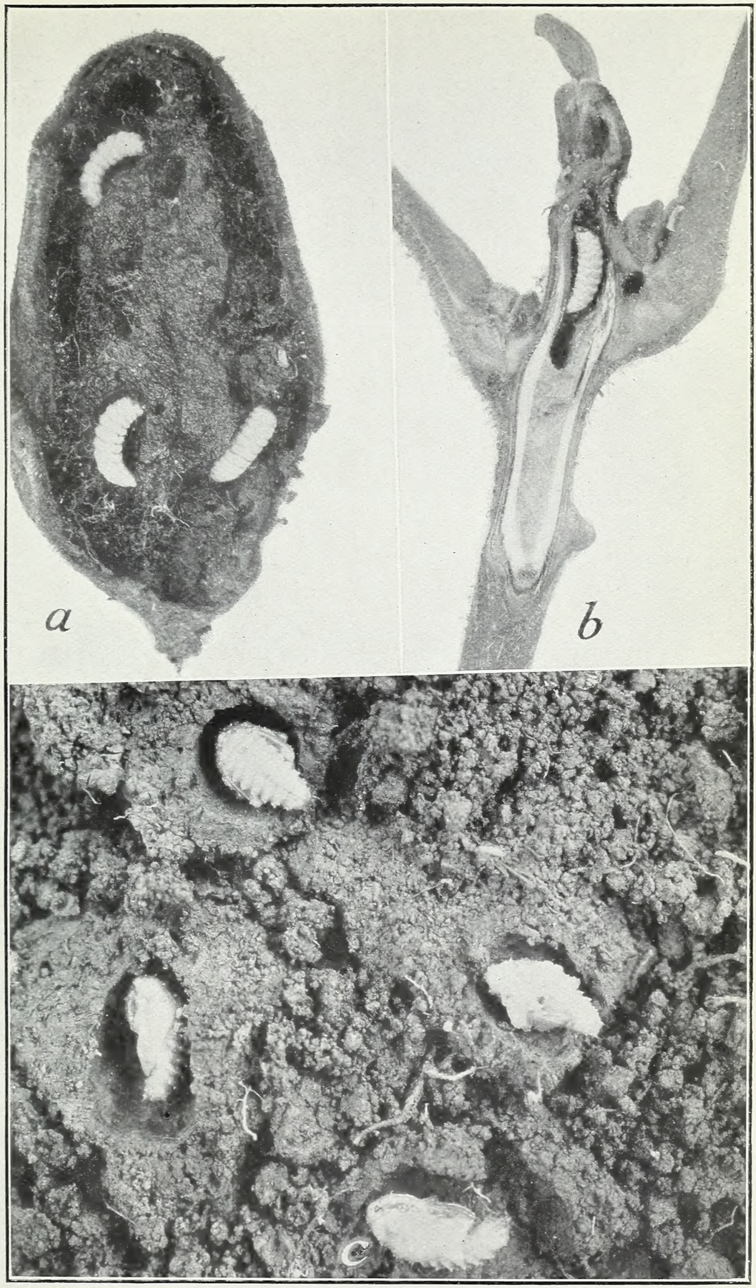
THE BUTTERNUT CURCULIO.

a, Adult curculio excavating egg chamber in butternut; *b*, adult female excavating egg chamber accompanied by male; *c*, curculio on tip of young butternut, a favorite resting place; *d*, eggs in young butternut exposed by cutting away the skin; *e*, eggs near tip of butternuts, a favorite place for oviposition while the nuts are small. All enlarged.



THE BUTTERNUT CURCULIO.

a, Egg and egg-punctures near tip of young butternut, egg exposed by removing skin of nut; *b*, eggs in shoot of Japanese walnut; *c*, eggs; *d*, larva boring in pith of Japanese walnut shoot. All enlarged.



THE BUTTERNUT CURCULIO.

a, Larvæ in husk of butternut; *b*, larva in shoot of Japanese walnut; *c*, pupæ within pupal cells in the ground. All slightly enlarged.

enough food to bring only one larva to maturity, but nuts that become infested when larger may contain from four to six larvæ which reach full growth. After leaving their feeding places preparatory to pupation the larvæ are active and crawl rapidly. When exposed to the light they have a habit of bending and catching the anal tip under the jaws and then releasing the tip with a jerk, sometimes throwing themselves in this way a distance equal to the length of the body. The larvæ issue chiefly in the early morning hours and enter the soil as quickly thereafter as possible. In West Virginia larvæ began to issue from butternuts on July 18 and continued to appear until September 4. Table 1 shows the rate of emergence.

TABLE 1.—*Time and rate of emergence of larvæ of the butternut curculio from half a bushel of butternuts at French Creek, W. Va., during the season of 1920.*

Date.	Number of larvæ.	Date.	Number of larvæ.	Date.	Number of larvæ.
July 18	3	Aug. 5	4	Aug. 23	9
19	0	6	2	24	3
20	16	7	5	25	1
21	0	8	1	26	1
22	9	9	8	27	0
23	1	10	4	28	0
24	5	11	5	29	0
25	11	12	2	30	0
26	153	13	2	31	0
27	22	14	7	Sept. 1	0
28	10	15	4	2	3
29	2	16	0	3	0
30	1	17	0	4	4
31	0	18	4	5	0
Aug. 1	13	19	1		
2	97	20	0	Total	464
3	40	21	1		
4	1	22	9		

As set forth in Table 1, 464 larvæ issued from half a bushel of infested butternuts over a period of 49 days. It is an interesting fact that emergence was much more rapid during cool than warm weather. For example, on the mornings of July 26 and August 2, the dates of maximum emergence of the larvæ, the temperature registered, respectively, 46° and 54° F. More than half the entire number of larvæ issued on these two mornings of unusual cold.

PUPA.

The pupa (Pl. III, *C*) is creamy white, the color deepening and the eyes becoming dark as the adult stage is approached. The length averages 10 mm. and the thickness 5 mm. The entire ventral surface is sparsely covered with short, stiff hairs. The pupa occupies a smooth-walled cell from 1 to 3 inches below the surface of the ground. Nearly a month is spent beneath the ground by the insect in the prepupa, pupa, and young adult stages and then it emerges as a fully developed beetle and seeks the branches of a host tree.

ADULT.

The beetle (Pl. I, *A*, *B*, and *C*) resembles very closely the common plum curculio, being brownish gray with a variable, whitish, curved line on each side of the thorax and a broad whitish band behind the middle of the elytra. The back is marked with prominent humps and ridges and is covered with short gray and whitish pubescence. The strong curved beak is nearly half as long as the body, and the body, exclusive of the beak, averages about 7 mm. in length. The general appearance of the beetle is rough and angular.

The young beetles issue from the soil in late summer and early autumn, 64 individuals issuing in West Virginia between August 17 and September 6. Of these beetles the maximum daily emergence of 13 took place on August 27. A few beetles continued to come from earth in rearing jars up to the middle of October. These young beetles reach the trees before those of the parent generation have all died, and, like them, feed sufficiently in the autumn on the surface of terminal shoots and leaf petioles to suggest their destruction with arsenical sprays in September or early October. The beetles go into hibernation, probably in litter on the ground, with the approach of freezing weather.

The beetles issue from hibernation in the spring at about the time walnut trees come into bloom and resort at once to their host trees. They may at this time be jarred in abundance from butternut trees, a few having been taken in West Virginia by jarring black walnut and hickory trees growing near butternut trees. With very few exceptions, however, the species jarred from black walnut at this season of the year has been *C. retentus* and those from hickory *C. aratus*. This usually holds good even where the three kinds of trees grow in close proximity.

Feeding begins in a limited way soon after the beetles appear on the trees, the food consisting of stem and leaf tissues of the new growth. The feeding marks in the stems are in the form of irregular pits reaching through the bark and are sometimes extensive enough to cause the leaves and tips to droop and die. Oviposition soon begins, the first eggs being laid in the new growth which forms before the fruit is large enough to be attacked. In the native butternut most of the eggs are withheld until the nuts are large enough to receive them, this being when the nuts are about an inch long. In young and tender nuts practically all the eggs are placed in crescent-shaped marks eaten into the husk near the blossom end. (Pl. I, *E*; Pl. II, *A*.) By means of an extrusive ovipositor the egg is thrust into a small pocket excavated beneath the tongue of skin on the concave side of the crescent. The beetles are often found resting upon the remnants of the blossom that project from the tip of the young nuts (Pl. I, *C*), and in excavating the egg chamber in such nuts the female beetle takes her position on this withered part of the blossom, and, with her head pointing toward the nut, proceeds to excavate the crescent-shaped egg chamber. On account of her method of work the concave side of the crescent faces the tip. (Pl. II, *A*.) It is not unusual to find a young butternut with a row of these crescent marks completely encircling the blossom end.

As the nuts develop and the husk becomes tougher the beetle changes somewhat her method of procedure, and instead of cutting out the crescents for her eggs, places them in simple cavities gouged into the side of the nut through small openings in the skin. Such cavities are usually arranged in groups, the skin about the wounds being marked by dark stains from slight exudations of juice and from excrement voided by the beetle during the excavating process. These groups of punctures often contain half a dozen eggs each, one having been found by the writer which contained 11.

NATURAL ENEMIES.

During this investigation two species of dipterous parasites have been reared in West Virginia from larvæ of the butternut curculio. These have been determined by Dr. J. M. Aldrich, of the United States National Museum, as *Chaetochlorops inquilina* Coq. and *Cholomyia longipes* Fab. Both species are rather abundant, the first-named, especially, rendering good service in holding the curculio in check. Other investigators have reared the following species from this host: *Metadexia basalis* G.-T., *Cholomyia inaequipes* Bigot, *Myiophasia aenea* Wied., and *Sigalphus curculionis* Fitch.

THE BLACK-WALNUT CURCULIO.[6]

In June, 1919, the ground beneath bearing black walnut trees (*Juglans nigra*) at French Creek, W. Va., was found to be strewn thickly with young nuts the size of small marbles. Examination showed that each nut contained a single dirty-white larva half an inch or less in length. A quantity of the nuts were collected and placed in rearing jars with the expectation that in due time beetles of *Conotrachelus juglandis* would be reared therefrom. When the beetles appeared, however, they were slightly different from *C. juglandis*, and specimens submitted to Mr. E. A. Schwarz, of the United States Department of Agriculture, were determined as *Conotrachelus retentus* Say, a species the habits of which had hitherto been practically unknown. Further observations proved that this species attacks commonly the young fruits of black walnut in many localities in the eastern part of this country.

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[6] *Conotrachelus retentus* Say; suborder Rhynchophora, family Curculionidae, tribe Cryptorhynchini.

DISTRIBUTION.

This species was described and named nearly a century ago by Thomas Say.[7] Since Say's description was published entomologists have from time to time collected specimens of the beetle, but no data on the feeding habits of the species have found their way into print. There are records of beetles being collected at Allegheny, Pa., Topeka, Kans., Mendenhall, Miss., and Haulover, Fla. During the present investigation the writer has collected the species at Harrisburg and York, Pa.; Hagerstown, Cumberland, and New Windsor, Md.; Morgantown and French Creek, W. Va.; Fincastle, Gala, Lick Run, Marion, McDowell, Oak Ridge, Pulaski, and Radford, Va.; and Black Mountain and Hickory, N. C.

FOOD PLANTS.

No food plants of this curculio seem to be known other than the black walnut (*Juglans nigra*) and butternut (*J. cinerea*). Of these two, the black walnut is much preferred, only one beetle of the species having been obtained in extensive rearings from butternut. Hamilton records taking the beetles by beating red oak sprouts, and the present writer has collected them from hickory trees growing close to black walnut. The occurrence of the beetles on both the red oak and hickory was probably accidental.

NATURE AND EXTENT OF INJURY.

Except for its different food plant, this species corresponds very closely in all its activities as well as in appearance with the butternut curculio. The adults feed on the tender shoots and leaf petioles and make oviposition scars and feeding punctures in young black walnuts similar to those made in butternuts by the other species. The larvæ develop in young black walnuts and cause the nuts to drop, usually before they are half grown. The larvæ are occasionally, but rarely, found burrowing in the tender shoots of black walnut.

In seasons when black walnut trees are bearing a light crop of nuts a large percentage of the crop may become infested and drop, but in years of heavy fruitage the curculios do no more than to effect an unimportant thinning of the nuts. The following notes of field observations indicate degrees of infestation such as were frequently noted. On June 15, 1920, 17 newly set black walnuts were picked from the lower branches of a tree growing in a parklike woods near Cumberland, Md. Of these 17 nuts, 16 contained curculio egg punctures and the other a feeding puncture. On the 16th of the same month 50 per cent of the nuts on trees growing along the highway at New Windsor, Md., were found infested. At French

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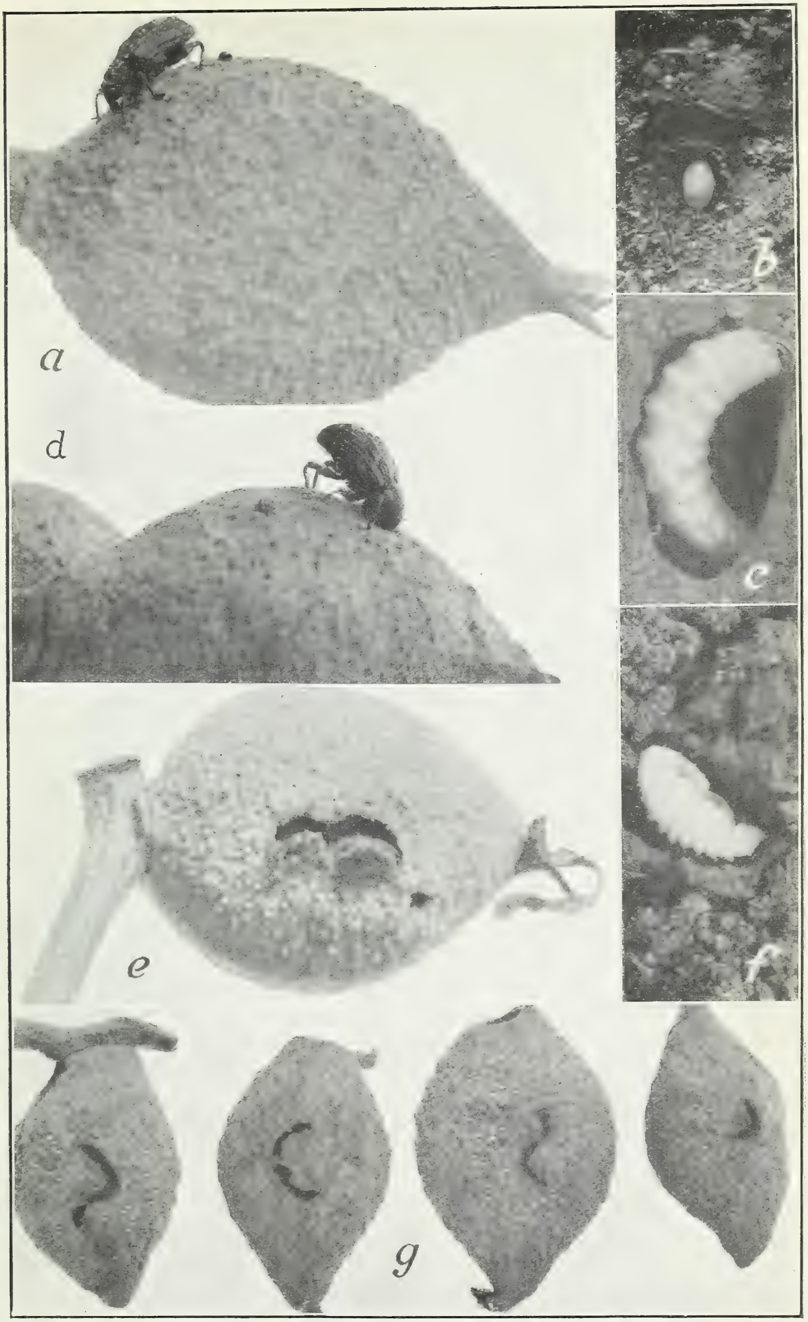
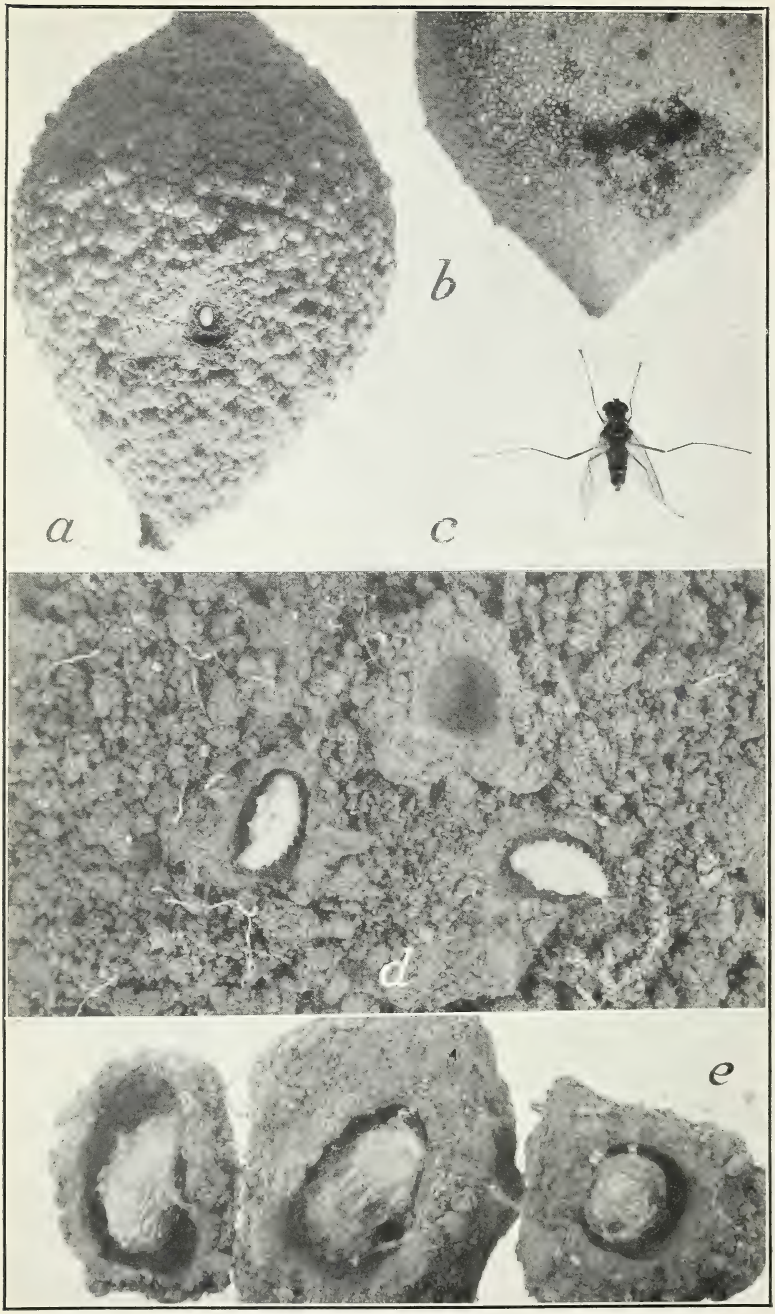
[7] SAY, THOMAS. ENTOMOLOGY OF NORTH AMERICA. (Leconte ed.) v. 1, p. 295. 1859.



THE BLACK-WALNUT CURCULIO.

a and *d*, Female beetles excavating egg chamber in young black walnuts; *b*, egg; *c*, larva constructing pupal cell in the ground; *e*, egg punctures in young walnut; *f*, pupa; *g*, egg punctures in walnuts.



THE BLACK-WALNUT CURCULIO.

a, Egg in natural position exposed by removing skin of young black walnut; *b*, group of egg punctures in half-grown black walnut; *c*, parasitic fly *Cholomyia longipes*; *d*, pupæ within pupal cells in earth; *e*, cocoons of the parasite *Thersilochus conotracheli* occupying the pupal cells of the curculio after killing and devouring the host larvæ. All enlarged.

Creek, W. Va., 400 young nuts were gathered at random from the lower branches of four black walnut trees growing in a pasture field. Of this lot of nuts 289 contained 466 egg punctures and the remaining 111 were sound. In another instance in the locality last mentioned 1,447 infested nuts dropped from one tree during the season.

So far as observations have been made, the black walnut curculio seems much more abundant and injurious in the latitude of Maryland and West Virginia than within the range of the black walnut farther to the north. In the vicinities of Trenton, N. J., Lancaster, Pa., Rochester and Lockport, N. Y., and Wallingford, Conn., a number of bearing black walnut trees were examined without finding any evidences of the presence of the curculio. Locality records by various entomologists and observations made during the present investigation indicate a southern rather than a northern range for this species.

LIFE HISTORY.

EGG.

The egg (Pl. IV, *B*; Pl. V, *A*) is oval, oblong, creamy white, surface delicately granulose, 1 mm. long by 0.7 mm. wide. Eggs that are deposited in young, tender nuts are placed beneath the flap of skin within a crescent-shaped puncture eaten out of the side of the nut (Pl. IV, *E*, *G*). In the more solid husk of half-grown nuts the eggs are inserted in less elaborate punctures which resemble pin pricks and extend directly into the husk. (Pl. V, *B*.) These simple egg punctures in the more nearly mature nuts are usually formed in groups of from three to six on the side of the nut.

About a dozen eggs deposited in nuts on the trees on July 15 hatched on the morning of July 22 and an equal number deposited on July 16 hatched on July 23, an incubation period in both cases of 7 days under natural conditions. Two other lots of eggs laid and kept in an open insectary hatched in five and six days, respectively. In West Virginia oviposition begins normally during the last days of May and continues through June and most of July.

LARVA.

The larva (Pl. IV, *C*) is creamy white with brown head, legless, and fusiform. It assumes naturally a curved position and is sparsely clothed with short, stiff hairs. The length is 11 mm. and the thickness 3 mm. As soon as hatched it begins to feed from the side of the oviposition wound, and, in young nuts, soon devours the whole interior. In the older nuts feeding is done chiefly in the husk. The infested nut adheres to the branch until the larva is at least half grown, and then drops, the larva continuing to feed while the nut dries and hardens on the ground. When the larva is full grown it ceases feeding, assumes a clearer cream color, and, after a period of a week or two of inactivity within the nut, cuts its way out through the shell and enters the ground to a depth of from 2 to 4 inches to pupate. Larvæ may be found in the nuts from early in June until late in September. In one lot of 805 larvæ which issued from infested black walnuts kept in rearing jars the first larva left the nut on July 14 and the last on September 21. These larvæ, like those of the butternut curculio, chiefly issued early in the morning and the largest numbers always in cool weather. In small green nuts only one larva matures to the nut, but two or three larvæ may develop together in a large nut. Apparently where several larvæ hatch and begin feeding in a small nut one individual always kills and devours the others. In two or three instances one larva was found killing and eating its fellow. On entering the ground the larva seeks a place where the soil is solid and fashions a smooth-walled cell (Pl. IV, *C;* Pl. V, *D*), where it rests for several days before pupating.

PUPA.

The pupa (Pl. IV, *F;* Pl. V, *D*) is white and is about 9 mm. long by 3 mm. thick. The abdomen, thorax, and wing pads are covered thinly with short, stiff hairs, these hairs being shortest on the wing pads. The pupa occupies an unlined earthen cell from 2 to 4 inches beneath the surface of the ground. The pupa stage covers a period of from two to three weeks.

ADULT.

The mature beetle (Pl. IV, *A* and *B*) is dull reddish-brown and covered with grayish pubescence. There is a lighter colored, indistinct, broad band behind the middle of the elytra and a vague, broken line of the same lighter shade on each side of the thorax. The snout is half as long as the body and the back is ridged and punctured. The length averages from 6 to 7 mm. This beetle in size and general shape resembles very closely the butternut curculio but its color markings and elytral sculpturing are less pronounced.

The newly developed beetles begin issuing from the ground in August; the first specimens were obtained in this investigation on August 7. In one rearing cage 75 beetles came from the ground between August 13 and September 2, the maximum emergence taking place from August 24 to 29.

In late summer and early autumn the young beetles may be found on their host trees, where they apparently feed on the leaf petioles before seeking their hibernation quarters. The beetles live through the winter, probably hidden in the duff at the surface of the ground, and resume activity in the spring in time to be on black walnut trees when the male catkins of the walnut are fully developed. As soon as the leaves and tender shoots appear the beetles attack them, sometimes feeding rather extensively. Soon thereafter they begin egg-laying in the young fruit. There is considerable variation in the time the fruit sets on individual trees of the black walnut in any locality and the beetles collect on the trees where the developing nutlets are at the stage just to their liking. This is immediately after the female catkins on the point of the nut are beginning to wither. Most of the eggs are deposited in nuts at this stage of their development, although the beetles continue to oviposit to some extent in nuts that are larger.

The beetles live normally throughout most of the summer and oviposit over a period of at least two months. Several overwintering beetles confined in screen cages placed over walnut branches on the trees lived until the last of August. It is thus possible in late summer to find the parent beetles and their mature offispring together on the trees.

NATURAL ENEMIES.

At least five species of insect parasites were found attacking the black walnut curculio in its larva and pupa stages. Three species of parasitic flies, determined by Dr. J. M. Aldrich as *Chaetochlorops inquilina* Coq., *Cholomyia longipes* Fab. (Pl. V, *C*), and *Fannia canicularis* L., were reared from this host in considerable numbers. Two hymenopterous parasites, determined by Mr. R. A. Cushman as *Triaspis curculionis* var. *rufus* (Riley) and *Thersilochus conotracheli* (Riley) (Pl. V, *E*) were also obtained in the rearing jars. Still another parasite, determined by Mr. R. A. Fouts as a new species of Belyta, was found in jars in which this curculio was being reared.

THE HICKORY-NUT CURCULIO.[8]

The hickory-nut curculio is very similar to the two species just discussed, but it attacks the immature nuts of various kinds of hickory instead of walnuts. The beetles appear upon the trees somewhat later in spring than the other two and lay their first eggs in hickory nuts that are at least half grown, although before the nut kernels have begun to form. The most conspicuous manifestation of the presence of the insect is the dropping of the infested nuts about midsummer. It is not unusual in July and August to find in some localities the ground beneath bearing hickory trees strewn thickly with green nuts. Examination of these nuts will disclose a brownish oviposition scar on the side of the nut (Pl. VI, *C*) and a whitish larva feeding within. (Pl. VI, *D*.) The dropping of nuts from this cause is sometimes very heavy.

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[8] *Conotrachelus affinis* Boh.; suborder Rhynchophora, family Curculionidae, tribe Cryptorhynchini.

HISTORY AND DISTRIBUTION.

This species was described and named in 1837 by Boheman.[9] Since the original description was published the species has been referred to occasionally by entomologists, but it has at no time attracted extensive notice. It has been recorded from the States of New Jersey, Ohio, Virginia, West Virginia, Louisiana, Florida, and the District of Columbia.

FOOD PLANTS.

During the last 15 years the writer has reared this curculio frequently from hickory nuts in West Virginia. Pierce[10] has reared it from hickory nuts in Louisiana. Apparently its attacks are confined to the nuts of various species of hickory. In West Virginia the nuts of the pignut hickory, *Hicoria glabra*, seem to be preferred to those of other species, although shagbark hickory nuts, *H. ovata*, are sometimes attacked extensively. Nuts of *H. alba* and *H. minima* are attacked to some extent and it is probable that injury may occur to the nuts of all species of hickory that grow within the range of the insect.

LIFE HISTORY.

EGG.

The egg (Pl. VI, *B*) is oblong, elliptical, translucent white, the surface smooth and shiny. The average dimensions are 1 mm. long by 0.6 mm. thick. The eggs hatch in from five to seven days.

LARVA.

The larva (Pl. VI, *D*) is white with light brown head, full-grown specimens measuring 12 mm. in length. The larvæ are practically identical with those of the preceding species except that they taper somewhat more abruptly at the anal end than *Conotrachelus retentus*, and the bristles, with which the body is sparsely clothed, are shorter and less conspicuous than in *C. juglandis*. They are found feeding singly in fallen nuts during the months of July and August. The infested nuts drop about 20 days after oviposition takes place, or about 2 weeks after the larvæ begin to feed. At the time of dropping, the nuts average from one-half to two-thirds grown.

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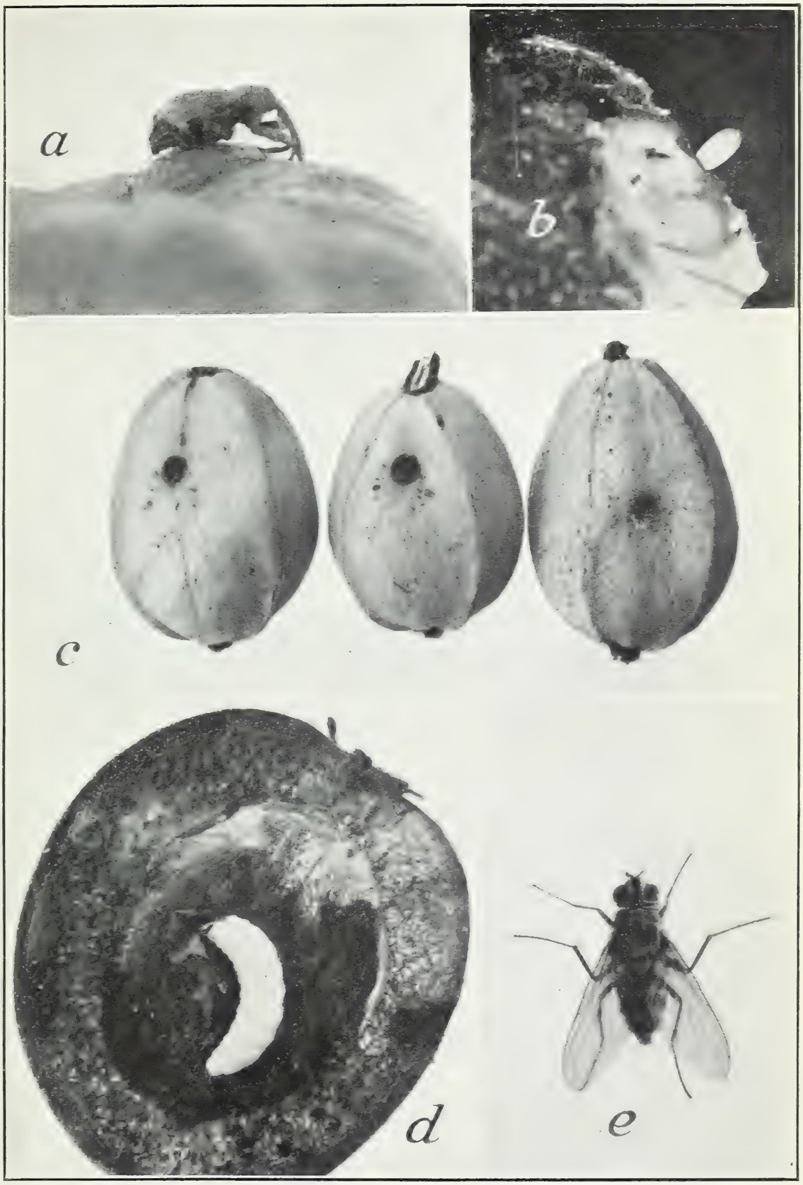
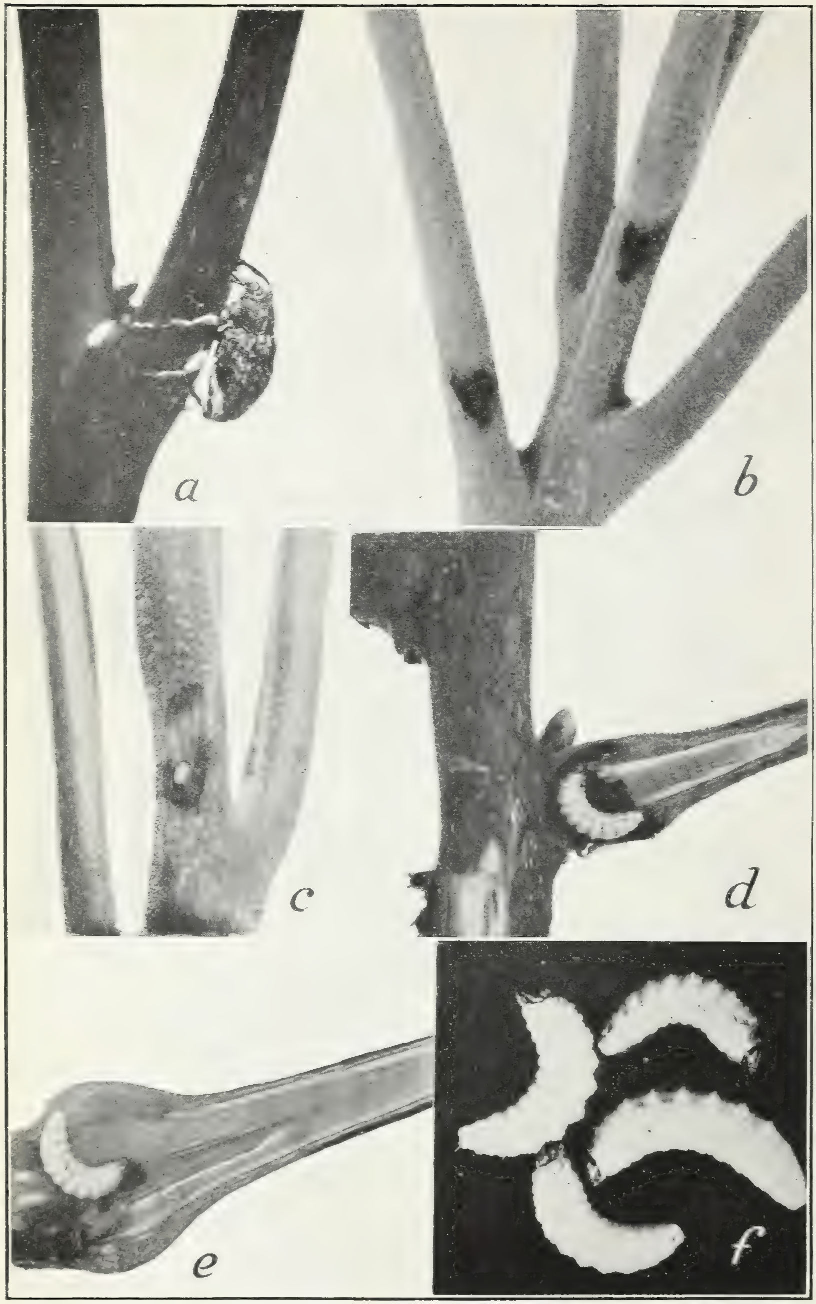
[9] BOHEMAN, C. H., *In* SCHOENHERR, C. J. SYNONYMIA INSECTORUM. GENERA ET SPECIES CURCULIONIDUM, t. 4, pars. 1, p. 429–430. 1837.

[10] PIERCE, W. DWIGHT. ON THE BIOLOGIES OF THE RHYNCHOPHORA OF NORTH AMERICA. Studies from the Zoological Laboratory of the University of Nebraska, No. 78. Nebr. State Bd. Agr., Rpt. Zoologist, p. 274. 1907.



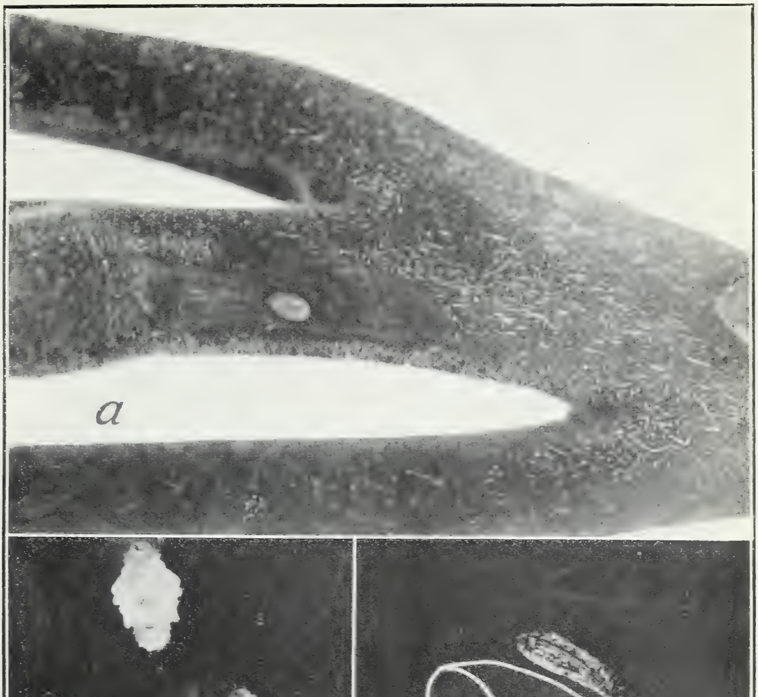
THE HICKORY-NUT CURCULIO.

a, Adult curculio resting on hickory nut; *b*, egg exposed by cutting away the husk of the nut from around the egg chamber; *c*, oviposition scars in shagbark hickory nuts; *d*, larva feeding in shagbark hickory nut; *e*, parasitic fly *Cholomyia longipes*.



THE HICKORY-SHOOT CURCULIO.

a, Adult excavating egg chamber in leaf petiole; *b*, oviposition scars; *c*, egg exposed by cutting away bark; *d* and *e*, larvæ feeding at base of leaf petioles; *f*, larvæ



THE HICKORY-SHOOT CURCULIO.

a, Egg in hickory shoot, exposed by removing bark; *b*, pupæ; *c*, hairworm parasite of larva by dead body of its host; *d*, curculio larva killed by larvæ of parasitic fly, *Chaetochlorops inquilina*, with pupæ of parasite on right; *e*, adult parasite *C. inquilina*.

The larvæ continue feeding in the nuts for 10 days or 2 weeks after they are on the ground and then leave through exit holes made at the oviposition scar.

PUPA.

The pupa is delicate white, sparsely covered with short bristles, as in *juglandis* and *retentus*, and is of the same general size and shape as the adult. Pupation usually takes place within unlined cells of earth an inch or two below the surface of the ground. In a few instances pupation was found occurring within host nuts that were buried beneath damp, fallen leaves. The pupa stage covers a period of approximately 30 days.

ADULT.

The adult (Pl. VI, *A*) is reddish brown with a conspicuous broad band of a lighter grayish shade behind the middle of the elytra. The snout is long, and the general size, shape, and markings of the beetle are similar to those of *C. juglandis* and *C. retentus*. It may be distinguished from *C. retentus* by its more reddish color, the light markings on the thorax and elytra often having a pinkish cast, and from *C. juglandis* by the less prominent humps and ridges of the elytra and also by the more pronounced reddish shade of the elytral and thoracic bands and markings.

The young beetles issue from the ground from August to October; they have appeared in rearing jars at French Creek, W. Va., from August 12 to October 15. Soon after emergence from their pupal quarters they go into hibernation and do not reappear until late the following spring.

Oviposition in the latitude of West Virginia begins late in June and covers a period of at least four weeks. The eggs are laid in circular or sometimes crescent-shaped scars on the side of the nut, the scars soon taking on a brownish or blackish color and becoming rather conspicuous. (Pl. VI, *C*.) It has been observed frequently that in nuts of *Hicoria glabra* the oviposition marks are made near the point of the nut, while in those of *H. ovata* the marks are directly on the side or near the stem end. Also, beetles developing from nuts of *H. ovata* average larger than those from the nuts of *H. glabra*.

The beetles are especially active at nightfall and have been observed ovipositing after dark.

NATURAL ENEMIES.

Numerous specimens of a parasitic fly were reared in September from larvæ of this curculio. (Pl. VI, *E*.) The species was determined by Dr. J. M. Aldrich as *Cholomyia longipes* Fab. A few specimens of another fly determined by Aldrich as *Myiophasia globosa* Towns. were also reared from the larvæ. Two hymenopterous species were found parasitic upon the larvæ; one of these was determined by Mr. R. A. Cushman as *Triaspis curculionis* var. *rufus* (Riley) and the other by Mr. C. F. W. Muesebeck as a new species of Microgaster. Pierce[11] records rearing the parasitic fly *Myiophasia aenea* Wied. from this host.

THE HICKORY-SHOOT CURCULIO.[12]

Soon after the growth of hickory begins in the spring the tender tips and leaf petioles may be found disfigured by dark, V-shaped marks on the bark about an eighth of an inch long. (Pl. VII, *B*.) These are the egg punctures of a small snout-beetle which may be known as the hickory-shoot curculio. Often these marks occur in series of from 5 to 10 along the shoot, one above each leaf axil. Examination of these marks usually discloses either the single white egg (Pl. VII, *C;* Pl. VIII, *A*) or a small white grub feeding in the stem (Pl. VII, *D* and *E*). The affected tip or leaf usually withers and drops as a result of the injury. No instance of serious loss from this insect has come under the writer's notice, but injurious attacks, especially to newly transplanted hickory trees, are a possibility.

DISTRIBUTION.

This species was described from Kentucky in 1824 and has since been recorded from Massachusetts, Connecticut, New Jersey, Florida, and Texas. The writer has found it abundantly at French Creek, W. Va., and has observed its work in other West Virginia localities.

FOOD PLANTS.

This curculio has been observed attacking the shoots of the following hickories in West Virginia: *Hicoria minima*, *H. ovata*, *H. alba*, *H. glabra*, and *H. pecan*.

LIFE HISTORY.

EGG.

The egg (Pl. VII, *C*; Pl. VIII, *A*) is oval, oblong, creamy white, semitransparent, and averages 1.1 mm. by 0.7 mm. It occupies a shallow cavity at the side of an elongate slit which the female beetle makes with her snout in the bark of tender twigs and leaf petioles. (Pl. VII, *A*.) After the egg is deposited the bark over the egg cavity and along the edges of the slit turns dark and the wound shows as a blackish, triangular spot on the green bark. (Pl. VII, *B*.) Several eggs laid on May 24 hatched on May 30, the incubation period being six days.

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[11] PIERCE, W. DWIGHT. A LIST OF PARASITES KNOWN TO ATTACK AMERICAN RHYNCHOPHORA. *In* Jour. Econ. Ent., v. 1, no. 6, p. 390. 1908.

[12] *Conotrachelus aratus* Germ., suborder Rhynchophora, family Curculionidae, tribe Cryptorhynchini.

LARVA.

The larva (Pl. VII, *D*, *E*, and *F*) is yellowish white with brown head and black jaws and is covered with scattering, short bristles, those on the dorsal surface of the last three segments being longer than those elsewhere. The length of the larva averages 10 mm. and the thickness at the middle 2 mm. Except for its slightly smaller size it is practically indistinguishable from those of other species described herein.

The favorite feeding place of the larva is in the heart of the bulb-like swelling at the base of the leaf petiole. (Pl. VII, *D* and *E*.) It also mines in the pith of the shoots and leaf stems, making burrows an inch or two long. The season of activity is in the spring and early summer when the new growth is tender.

PUPA.

The delicate, white pupa (Pl. VIII, *B*) is characteristic of the group and occupies an earthen cell from one-half inch to 2 inches below the surface of the ground. The pupa stage covers a period of not more than two or three weeks.

ADULT.

The beetle (Pl. VII, *A*) is considerably smaller than any other of the curculios discussed herein, an average specimen measuring 5 mm. in length and 2 mm. in thickness. The color is dull grayish brown with a more or less indistinct, broad band of yellowish pubescence behind the middle of the elytra and a narrow line of the same color on each side of the thorax. The snout is stout and curved and as long as the head and thorax combined.

The newly transformed beetles issue from the ground in midsummer and probably spend thereafter a period of comparative inactivity on hickory trees before hibernating in the autumn. With the bursting of hickory buds the following spring they reappear and begin ovipositing as soon as the shoots are a few inches long. They feed rather freely at this time, eating out small pits which extend through the bark of the young growth. Beetles were found frequently hiding between the folds of the expanding buds of hickory. In ovipositing the female spends 30 to 40 minutes in preparing a place for the egg, and while thus engaged is often guarded closely by a male.

NATURAL ENEMIES.

The larvæ while feeding and developing became rather heavily parasitized, at least 50 per cent of them dying from this cause during the two seasons they were kept under observation. Three species of flies, determined by Dr. J. M. Aldrich as *Myiophasia globosa* Towns., *Cholomyiæ longipes* Fab., and *Chaetochlorops inquilina* Coq. (Pl. VIII, *D* and *E*), were reared from the larvæ. Two larvæ in rearing cages died when full-grown and from each of their bodies there issued a hairworm several inches long, the species of which was not determined (Pl. VIII, *C*).

METHODS OF CONTROLLING NUT-INFESTING CURCULIOS.

The dropping of curculio-infested walnuts and hickory nuts before the larvæ within them mature affords an opportunity for destroying the young insects by collecting and burning, or otherwise disposing of the fallen nuts. This method can be resorted to with success, however, only in cases of isolated trees or plantations. In localities where the nut trees abound in woods a sufficient number of the curculio beetles will develop on them to visit and injure any near-by plantations of the same kind. Where this means of reducing the insects is practiced collections should be made as often as once a week in order to secure the nuts before the larvæ leave them to enter the ground for the completion of their development.

All the curculios discussed herein do more or less feeding in the beetle stage before oviposition begins in the spring. A considerable part of this food consists of the surface tissues of stems, leaves, and fruit. This makes it possible theoretically to destroy the beetles before their eggs are laid by spraying with arsenical poisons. Limited experiments by the writer indicate that lead arsenate applications soon after growth starts in the spring can be counted on to give good results in reducing injury, at least from the butternut and black walnut curculios.

Britton and Kirk[13] have found that spraying walnut trees with lead arsenate at a strength of 6 pounds to 50 gallons of water is an effective method of controlling the butternut curculio. Morris,[14] in writing of attacks of the butternut curculio which were so extensive as to kill nearly 300 young English walnuts and several hundred young Japanese walnuts, states that subsequent spraying with 1 pound of lead arsenate to 10 gallons of water killed the beetles and prevented further injury.

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[13] BRITTON, W. E., and KIRK, H. B. Op cit.

[14] MORRIS, ROBERT T. METHOD FOR COMBATING THE WALNUT WEEVIL. *In* Amer. Nut Journ., v. 10, no. 5, p. 71. 1919.

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